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THE THEORY OF LAKES AND MOUNTAIN BARRIERS IN EARLY AMERICAN GEOLOGY

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Between 1750 and 1820, views upon American physiography were embraced in a conception of mountain barriers holding back an enormous lake which occupied the central part of the United States. The great barrier which held back this lake was the Blue Ridge. It was thought that modern Appalachian topography was formed when this lake broke through the barrier and drained the area now occupied by the central states.

The theory probably arose at Philadelphia and gained widespread popularity in the scientific world of the day, especially through the writings of Jefferson and Volney. It was the first attempt of American and European scientists to explain the physiography of the eastern United States, and was based upon the belief that mountains were formed before rivers and lakes, a belief which survived until 1880. The theory presented a strong appeal to active imagination. It is still encountered locally in the east where it is used to explain the origin of gaps in the Blue Ridge.

The early seventy years of American geology (1750–1820) were necessarily a period of speculation. There were no accurate maps to show the positions of the Appalachian mountains and Blue Ridge, and little was known of their elevation. Thomas Jefferson determined the elevation of some of the peaks and gaps in the Blue Ridge of Virginia, yet he thought that the Peaks of Otter were the highest mountains in the United States. The geologists, Maclure and Volney, pursued their studies on foot. Travel in general was by coach, which afforded little opportunity for the study of natural features. Many basic principles in geology were not developed at this period, and many who wrote upon geology had no particular training in that field.

Thomas Hutchins (1730–1789), the first American topographer, outlined the physical features of the eastern colonies in 1778. On his map the Appalachian ridges extend as far west as Fort Pitt. and swing southwestward in a great arc from Pennsylvania to Muscle Shoals (sic) near Mississippi River.

It is probable that the conception of a great inland lake held in by an eastern mountain barrier first spread from Philadelphia, which was then the intellectual center of middle-eastern United States. The first reference to this theory known to the writer, is found in the travels of Peter Kalm[1] who, while in America (1748–1751), spent some time near Philadelphia with the botanist Bartram.

Mr. Bartram was a remarkable observer for the times. Kalm asked him "Whether he had observed in his travels that the water was fallen, and that the sea had formerly covered many places which were now land." Bartram answered that from his experience he was convinced that the greatest part of the country had formerly been under water. He listed many reasons for this belief. (1) Oyster shells occur in the Blue Mountains and its valleys, three hundred miles from the sea. They are found loose and also in the rock. (2) They are dug up in Virginia, Maryland, New York and Philadelphia. Trees, roots and oak leaves are encountered by well diggers at Philadelphia and other places. (3) Valleys bounded by mountain ridges in this country once were covered by lakes. The water finally broke through the mountains and released the lakes. "Such vallies and cloven mountains are very frequent in the country, and of this kind is the peculiar gap between two mountains, through which a river takes its course, on the boundaries of New York and Pennsylvania. The people, in a jest, say, that the opening was made by the devil, as he wanted to go out of Pennsylvania into New York." (4) "When savages are told that shells are found on these high mountains, and that from thence there is reason to believe that the sea must formerly have extended to them, and even in part flown over them, they answer, that this is not new to them, they having a tradition from their ancestors among them, that the sea formerly surrounded these mountains."

Bartram seems to have believed that the mountain barriers were broken and lakes released at the time of the Deluge.

[1]Peter Kalm, "Kalm's Travels in North America," translated by J. R. Forster, London (1772), 2nd ed.

Later observers make little mention of the Deluge, but thought that the breaks in the mountains were made by natural rather than supernatural processes. Thomas Twining, who later helped to lay the foundation of the Indian Empire, said that it was common belief among American geologists that the "Blue Mountains were once the boundaries of an immense lake till the Susquehannah, Potomac, and other rivers burst through them."[2]

Smyth in 1784, writing of the eastern central states, mentions "the mountains suddenly broken through and severed by mighty rivers."[3]

Maclure was interested in the classification of rocks and avoided any discussion of the theory.

Merrill[4] quotes S. L. Mitchell (1818) upon the "Theory of Barriers." Mitchell, however, merely expanded the general theory from the viewpoint of the northern states. The theory had been in existence for at least seventy years prior to Mitchell's article. His work followed and amplified the opinions of Volney and other writers upon the topic.

Thomas Jefferson popularized the conception of barriers which he may have encountered at Philadelphia. Travelers in the United States generally visited Jefferson at Monticello. In the hall at Monticello they saw mammoth bones, "maps traced by the Indians on leather," and other curiosities. They talked with him upon Indians, climate, timber, Natural Bridge, and the natural wonders of Virginia. For years Mr. Jefferson served as a voluntary tourist's bureau. English travelers listened and sometimes disagreed, but French and German travelers with greater confidence in his opinions, left Monticello convinced of the truth of his scientific theories.

Jefferson's colorful description of the break in the Blue Ridge at Harper's Ferry placed the conception of barriers upon a firm footing for many years.[5]

"The passage of the Patowmac through the Blue ridge is perhaps one of the most stupendous scenes in nature. You stand on a very high point of land. On your right comes up

[2]Thomas Twining, "Travels in America 100 Years Ago," (1894), Harpers, New York, p. 99.

[3]J. F. D. Smyth, Esq., "A Tour of the United States of America," (1784), 2 vols., London.

[4]George P. Merrill, "The First One Hundred Years of American Geology," (1924), New Haven, Yale University Press, pp. 50–53.

[5]Thomas Jefferson, "Notes on the State of Virginia," (1800). Baltimore, W. Pechin, pp. 20–21. Many editions. The Notes were first written in 1781.

the Shenandoah, having ranged along the foot of the mountain an hundred miles to seek a vent. On your left approaches the Patowmac, in quest of a passage also. In the moment of their junction they run together against the mountain, rend it asunder, and pass off to the sea. The first glance of this scene hurries our senses into the opinion, that the earth has been created in time, that the mountains were formed first, that the rivers began to flow afterwards, that in this place particularly they have been dammed up by the Blue ridge of mountains, and have formed an ocean which filled the whole valley; that continuing to rise they have at length broken over at this spot, and have torn the mountain down from its summit to its base. The piles of rock on each hand, but particularly on the Shenandoah, the evident marks of their disrupture and avulsion from their beds by the most powerful agents of nature, corroborate the impression. But the distant finishing which nature has given to the picture, is of a very different character.— It is a true contrast to the foreground. It is as placid and delightful, as that is wild and tremendous. For the mountain being cloven asunder, she presents to your eye, through the cleft, a small catch of smooth blue horizon, at an infinite distance in the plain country, inviting you, as it were, from the riot and tumult roaring around, to pass through the breach and participate of the calm below. Here the eye ultimately composes itself; and that way too the road happens actually to lead. You cross the Patowmac above the junction, pass along its side through the base of the mountain for three miles, its terrible precipices hanging in fragments over you, and within about 20 miles reach Fredericktown, and the fine country round that. This scene is worth a voyage across the Atlantic. Yet here, as in the neighborhood of the Natural Bridge, are people who have passed their lives within half a dozen miles, and have never been to survey these monuments of a war between rivers and mountains, which must have shaken the earth itself to its centre."

A "lofty crag upon the margin of the river," from which Jefferson is said to have viewed the scene, was once called "Jefferson's Rock." Jefferson told Volney that he had taken his description from "the report of a French engineer, who, during the Revolutionary war had scaled the hill." This account of Jefferson was frequently quoted in American geographies where it may be found as late as 1850.

Count C. F. Volney, an authority of the times upon history and geography, visited the United States in 1795, and traveled extensively for three years. He hiked through rural America making observations upon climate, soils, and geology. Twining met him in 1795 and said "he was cold and satirical. . . . He was little pleased with America, and where he was not pleased he expressed himself with much severity." The following episode recorded from rural Virginia may have been typical of Volney:[6]

"Some thirty or more years ago, at the close of a summer's day, a stranger entered Warrenton. He was alone and on foot, and his appearance was anything but prepossessing; his garments coarse and dust-covered, like an individual in the humbler walks. From a cane resting across his shoulder was suspended a handkerchief containing his clothing. Stopping in front of Turner's Tavern, he took from his hat a paper, and handed it to a gentleman standing on the steps. It read as follows: 'The celebrated historian and naturalist, Volney, needs no recommendation from G. Washington.' "

Volney talked with Jefferson, Washington, "Mr. Barton" and many others, and his views were colored by their opinions. It seems more than probable that Volney developed the idea of barriers after his talks with Jefferson, although his views are stated as if they were original. Volney brought this theory into a position of the greatest importance in American geology.

He believed[7] that the Blue Ridge was once a great barrier and that the Great Lakes are a shrunken remnant of a great inland sea which stood behind it. He thought that the sea has broken through at Harper's Ferry and at other places. The breaks in the Blue Ridge were produced by stream erosion and by earthquakes. High gaps in the ridge were formed by the first efforts of the lake to reach the sea. Terraces along the Ohio he believed to be due to successive lower water levels as the barriers were lowered. Horizontal strata west of the ridges were deposited in this ancient sea and rivers washing in trees laid down the beds of coal. Coal beds in Virginia east of the Blue Ridge may have somehow been produced by earthquakes, although the beds near Richmond were laid down in a basin which was held in by rocks at the present Fall line.

[6]Henry Howe, "Historical Collections of Virginia," (1845), p. 261.

[7]C. F. Volney, "Tableau du Climate et du Sol des Etats Unis d'Amerique, etc." (1803). Several editions. English translations by C. B. Brown, Philadelphia, (1804).

According to Volney's map, the great eastern barrier extends from the southern side of the St. Lawrence in Nova Scotia southwestward to include the White Mountains of New Hampshire, the Highlands of New Jersey, and the Blue Ridge to Alabama. Appalachian ridges run into this mountain chain in such a manner as to make many isolated interior basins. From Alabama, the chain swings sharply westward to the junction of the Tennessee and Cumberland rivers with the Ohio. Here the mountain was presumably broken by the Mississippi. The "Haute Louisiane" west of the river extends the highland westward to the Stony Mountains. This chain extends northward to the Mackensie River. He places an east-west mountain chain north of the Great Lakes from the Stony Mountains to Labrador. The St. Lawrence breaks through this chain and also through an inner chain which strikes across the east end of Lake Ontario from the Adirondack Mountains. His great inland sea or lake stood within this barrier of mountains. Volney made no definite attempt to explain the origin of the ridges.

French travelers followed Jefferson in their opinions upon American geology. It remained for the Marquis De Chastellux[8] to polish up the theory by using it to explain the origin of Natural Bridge in Virginia.

The first accurate survey of the bridge was made by Baron de Turpin under Count de Rochambeau and at the instigation of the Marquis De Chastellux. De Turpin took from "every part of the arch, and of its supporters" pieces of stone all of which were found to dissolve in aqua fortis and says that "these rocks being of a calcareous nature, exclude every idea of a volcano, which besides cannot be reconciled with the form of the bridge and its adjacent parts." Nor could a current of water break through here and make the bridge. Chastellux outlines the theory of lakes behind mountain barriers and says that rivers rising in the Alleghanies "have opened ways for themselves to the sea, by piercing the mountains at angles, more or less approaching to right angles, and forming more or less spacious valleys. Natural Bridge was formed by this process where water broke through." Other bridges formed in this manner have collapsed since.

While such views were held by famous men, Gilmer in 1815,

[8]Marquis De Chastellux, "Travels in North America," (1787), 2 vols. London.

after visiting the bridge with its owner, Jefferson, refused to accept this theory, and in this manner Jefferson lived into the day of modern science. In a remarkable article before the American Philosophical Society Gilmer said[9] that the bridge was due to solution effects in limestone.

Observers at an early date attacked Volney's conception of inland lakes. David Thomas,[10] an astute New York traveler, made a westward journey by coach in 1816 to study the "Waubash lands in the New Purchase." Wherever the coach stopped, he continually tested Volney's theories against personal observations. Although Volney was "said to be a genius of the first order in physical geography," he found that the knobs at New Lexington which Volney said once held back a great lake, could not have done so, since the rocks below their summits are not alluvial but are calcareous and siliceous (secondary). He condemns the tendency of the geologists of the time to "imagine that every valley which pours a stream through mountain ridges, was formerly the bed of a lake." He states that the Blue Ridge, for example, was too massive for its breaches to have been made by pressure of water, nor could these ruptures have been made by earthquakes as Volney suggested. He says that Volney's theory is absurd because the Knobs do not extend across the valley of the Ohio or the White River, because the secondary strata including coal beds and limestone, are not the kind of rocks to be laid down in recent lakes, and that the marine shells in the rocks west of Volney's lake can not be explained according to his principles."[11]

The conception of mountain barriers and inland seas died obscurely. Scientists lost faith in it before a better theory was advanced. Writers of geological texts avoided it. Except in

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[9]Francis W. Gilmer, "On the Geological Formation of Natural Bridge, Virginia," (1818). Trans. Am. Phil. Soc., vol. I, new ser., No. 13.

[10]David Thomas, "Travels Through the Western Country in the Summer of 1816," (1819), Auburn, N. Y.

[11]Although beyond the scope of this paper, it should be said that from his study of coal and invertebrate fossils, Thomas caught a glimpse of organic evolution 40 years before the publication of the Origin of Species. He says, p. 260:

"The grand order of our system is to spring, to flourish and to die. The period for which many* plants and animals were intended, is past; and like the individuals of every race, whole species have perished. The space assigned them has been filled; new orders arise; and combinations more beautiful are unfolded. The sheep tenants the deserted ranges of the wolf, and the yellow gleams of harvest, succeed the dark foliage of the forest.

*It is questionable whether the beds of coal are the remains of any vegetable species now in existence."

school geographies, little mention is made of this theory after 1820.

In 1821, Wilson[12] attacked Volney's Views, Jefferson's Notes, and the opinions expressed in the appendix to an early American edition of Cuvier's theory. He said that the barrier does not have sufficient height to pond up a large lake, and that the lake could not have broken through at six points at once.

Charles Lyell visited America in 1841–42. He calls special attention to the *absence of lakes in the Appalachians.* He may have been thinking of the supposed lakes when he said "it is singular that there are no lakes in the Appalachian chain, all the rivers escaping from the longitudinal valleys through gorges or cross-fissures, which seem invariably to accompany such long flextures of the strata as characterize the Alleghanies or the Jura."[13]

From discussions which arose upon the origin of these "cross-fissures" came the conception of antecedent streams, and the development of modern physiography by Davis.[14]

Although abandoned many years ago by science, the theory of lakes and mountain barriers is not entirely dead to this day. It is still encountered in rural Virginia and perhaps at other places, where it is probably a survival from the past. Sometimes it arises spontaneously. Dyott,[15] a South American explorer has recently invoked the theory to explain the geology of the Amazon valley.

In 1902 the existence of an inland lake held back by the Blue Ridge was suggested by the writer of a soil report.[16] Because waterworn cobbles occur in the fans at the western slope of the Blue Ridge "this talus slope has been subjected to the action of water, probably while forming a shore of an inland sea.

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[12]J. W. Wilson, "On the Bursting of Lakes Through Mountains," Am. Jour. Sci., (1821), pp. 252–3.

[13]Charles Lyell, "Travels in North America," (1845), 2 vols. New York, p. 240.

[14]William Morris Davis, "The Origin of Cross Valleys," (1883), Science, I, pp. 325–27, 356–57.

[15]G. M. Dyott, F. R. G. S., "Man Hunting in the Jungle," (1929), Bobbs-Merrill Co., pp. 111–112.

[16]Charles N. Mooney and F. E. Bonsteel, "Soil Survey of the Albemarle Area, Virginia," U. S. Department of Agriculture, Bur. of Soils, (1902), p. 207.

PROTOZOAN PARASITES OF THE ORTHOPTERA, WITH SPECIAL REFERENCE TO THOSE OF OHIO[1]

I. Introduction and Methods

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INTRODUCTION

This work is primarily a distributional and ecological study of the protozoan parasites of Ohio Orthoptera, exclusive of the domestic cockroaches, *Blattella germanica*, *Blatta orientalis*, and *Periplaneta americana;* and also excluding the wood-eating roach, *Cryptocercus punctulatus*. The Orthoptera were taken from July, 1932 to October, 1933 in Franklin County and the six contiguous counties of central Ohio, and in the southeastern portion of Washington County in southeastern Ohio; also sporadically in four other counties of Ohio and the Lake Michigan sand dunes of Indiana.

Specifically, the purpose of this study was to determine the distribution of protozoan parasites in all available species of Orthoptera in a given region, and to learn something of the relationship between life history and ecology of parasite and life history and ecology of host. In addition, a classified, annotated list of the protozoan parasites of the Orthoptera of the world was compiled from the literature, a key for the identification of these protozoa was constructed, and a complete bibliography was assembled.

A comprehensive survey of the protozoan parasites of all the Orthoptera of a given geographic region has not previously been made, although S. F. Bush has published (1928) such a study of the Gregarinida present in the Acrididae (locusts or short-horned grasshoppers) of a region in South Africa.

The terminology of this work has been selected, for the most part, from Calkins, 1933 (general protozoology), Wenyon, 1926 and Kudo, 1931 (parasitic protozoology), and Watson, 1916, p. 10 (Gregarinida).

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[1]Contributions from the Department of Zoölogy and Entomology, number 112, part 1.

Professor W. J. Kostir, of the Department of Zoology and Entomology, The Ohio State University, suggested the possibilities in this field and kindly undertook the supervision of the research. Mr. Edward S. Thomas, curator of Natural History of the Ohio State Museum, helped greatly in many ways, particularly in the collecting and identifying of the Orthoptera. Dr. Theodore H. Hubbell, of the Zoology Museum, University of Michigan, generously devoted much time to the correction and revision of the classified list of orthopteran hosts examined by other investigators. The following persons also rendered valuable help: Dr. A. N. Caudell, Entomologist, United States National Museum; Dr. Richard R. Kudo, Department of Zoology, University of Illinois; Mrs. Ethel M. Miller, Botany and Zoology Librarian, The Ohio State University; Professor Catherine B. Semans, Youngstown College; and Dr. B. P. Uvarov, British Museum of Natural History.

METHODS

Orthoptera were collected extensively throughout central Ohio and a portion of Washington County, and less so, in several other localities, with a view to obtaining as large a number of species from as great a variety of habitats as possible. There was no thought of collecting at regular intervals from the same localities, as that was not possible in the time available. The majority of the collections were made during the summer and early fall of 1933; hence no attempt was made to compare results from the same seasons (summer and fall) of the two different years; and, also, the number of specimens of no one species was great enough to justify such a procedure. Most of the collecting was done by net sweeping, although all known methods were used.

The following ecological factors were recorded for each locality in which collections were made: Uppermost geological stratum, kind of soil, topography, average soil moisture and soil pH, plant association, and the general weather conditions. The pH was determined by the use of the Soiltex colorimetric method—a simple modification of that of M. F. Morgan (1927, p. 387; also described by E. F. Snyder, 1928, p. 18)—supplemented by the Hellige colorimetric method. In the Soiltex method, a small portion of pulverized soil is placed in a trough of waxed paper which is held on a slant. Several drops of indicator solution are dropped on the upper end of the soil

until a globule of liquid appears at the lower end. A small, clear drop of the liquid is drawn away from the soil with a clean knife blade and its color is compared with a color chart. An average discrepancy of 0.32 occurred between determinations made by this method and the quinhydrone electrometric method on four samples of soil covering a range of 5.58 to 7.71. The error was, no doubt, partly the result of the presence of pigments in the soil. The same method was used in determining the pH of the anterior end of the mid-intestine of thirty-seven orthopteran specimens, in an attempt to correlate parasite prevalence with degree of acidity.

The general weather data are omitted from this paper because these were found to be of little significance over so comparatively short a period of collecting.

The captured insects were kept alive in glass jars, usually containing pieces of paper or dry plant material to reduce the humidity—apparently the greatest factor in the loss of insect material—and also to prevent the insects from striking one another. A rapid change of temperature was even more deleterious than high humidity, but it did not occur so often. The examination was usually made immediately after taking the insects, hence, except in special cases, no attempt was made to provide them with food.

In preparation for the examination of insects for parasites, a thorough study of insect morphology was made, including the histology of the alimentary tract of the differential locust (*Melanoplus differentialis* (Thomas, 1865) Brunner, 1885).

The perfected routine as used in the examination of the insects may be resolved into the following steps:

1. As a preliminary step the following information was recorded: Accession number of the insect; age and sex; the locality (characterized ecologically in a field record-book) where the insect was taken; the dates of capture and examination; and, later, the parts examined and the percentage of saline (0.85% sodium chloride) solution used in the temporary mounting. An experiment on the effect of three percentages of saline (0.65%, 0.75%, 0.85%) and distilled water on a delicate gregarinid (*Gregarina galliveri* Watson) which was available in comparatively large numbers, showed that there was little appreciable difference, except with the distilled water, where distortion (rounding) was produced somewhat earlier.

2. The insect was slit anteriorly on the midventral line with a small pair of scissors. In rare cases where the insects were extremely small and active, they were anesthetized with tobacco smoke. The severing of the ventral nerve trunk in the thoracic region proved to be no more effective in stunning the insect than the longitudinal slitting.

3. The cut edges were pushed well apart with a pair of forceps and, with a second pair, the alimentary tract was broken from its extreme connections and removed to a clean glass slide into a few drops of saline solution. (See step 11 for the method of examining the intestinal contents of cockroaches from flagellates and ciliates.)

4. The insect was pinned and labelled.

5. The slide mount was placed on the stage of a low-power (×10.5 to ×30) binocular microscope. The alimentary tract was broken apart by means of two pairs of forceps—cleaning them after each operation—into fore-intestine, mid-intestine (removing the enteric ceca for separate consideration), and hind-intestine—or whatever divisions of the latter were present. Each section was placed in a separate drop of saline solution.

6. The alimentary tract and malpighian tubules were examined externally for celomic parasites, and then, with two stout insect pins (cleaned after each operation), each section was torn into small shreds, the number and position of the larger Gregarinida being noted. The malpighian tubules were left more or less intact for separate examination.

7. The drops of saline solution impregnated with gut contents were spread over the slide to make them as thin as possible and were examined—usually without a cover-glass, the use of the latter making it difficult to obtain organisms for permanent staining—with the ×60–100 combination of the microscope, stepping up the magnification as high as ×880 for minute flagellates. The examination was facilitated by the use of a graduated mechanical stage.

8. In a thorough examination of the temporary mount, everything of apparent significance was recorded, measurements of the organisms being determined by means of a calibrated ocular micrometer. Drawings were made with or without the use of a camera lucida, depending upon the amount of movement in the organisms. Weak stains were used at the start but were abandoned in favor of the saline mount followed by the permanent staining of all representative parasites, including helminths.

9. Cysts of interest, if not permanently mounted, were put in a watch glass or the well of a concavity slide and kept in a moist chamber, but a technique for invariably bringing about cyst dehiscence was not perfected, as the number of cysts was too small.

10. Representative gregarinids (i. e., of the order Gregarinida) were removed, by means of a capillary pipette, to a watch glass for fixing and staining. It was found to be impracticable to make permanent mounts of flagellates from saline, as it was difficult to make them adhere to glass.

11. The fixing and staining of flagellates and ciliates (from step 3): A portion of the hind-intestine—usually the colon—of cockroaches was mixed with a small drop of sterile horse serum (adhering agent) on a clean cover glass, spread over the entire surface of the latter, and plunged into a fixing agent (preferably Kahle's fixing fluid: 32%, 95% ethyl alcohol; 11%, 40% formaldehyde; 4% glacial acetic acid; 53% distilled water) in a syracuse watch glass for about two hours;

then it was passed through 70% and 50% alcohol down to 30%, at fifteen-minute intervals, and stained ten to fifteen minutes by Ehrlich's hematoxylin (not longer, as in the case of other hematoxylin methods, otherwise overstaining results), and back up through the same alcohols to absolute alcohol and then xylol for the mounting in balsam.

12. The fixing and staining of Gregarinida (from step 10): Instead of using adhering agents, which created an undesirable background when stained (except for the smallest specimens), the saline was removed and the fixing agent (preferably Kahle's) applied by means of a capillary pipette—the method used throughout the entire fixing and staining procedure. Kahle's fluid was left about two hours, followed by two changes of 70% alcohol (two hours each), 95% alcohol (two minutes), the stain, Fast Green FCF (two minutes), 95% alcohol again (one minute), absolute alcohol (five minutes). The organism was placed by means of a capillary pipette directly into balsam (mixed with xylol) on a slide cleaned with xylol and a clean cover-glass was applied.

The Kahle's-Fast Green method is a slight modification of that suggested by C. H. Kennedy (1932) for the staining of the cytoplasm of the insect cell, and was discovered to be effective for the Gregarinida through the staining of sections of the alimentary tract of *Melanoplus differentialis* (Thomas) containing sporonts of *Gregarina rigida* (Hall). No additional nuclear stain is necessary, as the refractive index is quite different from that of the cytoplasm. Several other staining methods were tried, but none appeared to be as satisfactory as that described above.

All permanent slide mounts were placed in the author's private collection.

13. Every insect examined, irrespective of whether or not it was a host, was taken to Mr. Edward S. Thomas for identification. Many of the specimens were retained for the Ohio State Museum collection and were so labelled that they may be readily referred to. The remaining specimens (all of the hosts and many of the non-hosts) were placed in the author's private collection.

14. The permanent slide mounts were examined, and everything of significance was recorded, this information being compared with that acquired from the examination of the temporary mounts. The biometric method of M. E. Watson (1916, p. 42), modified, was adopted for the description of the Gregarinida. At least one representative gregarinid individual from each host individual was described in detail. The position of the nucleus was recorded, but as that structure may shift its position somewhat, as was observed in at least one case, it is doubtful that the information will prove to be of much significance. Hence, it will be withheld for further consideration.

TERMINOLOGY OF THE ALIMENTARY TRACT

Because of the confusion existing in the use of terms describing the divisions of the alimentary tract of Orthoptera, it is well to consider them at this time.

The embryological divisions of the alimentary canal are

the fore-, mid-, and hind-intestine. In the adult fore-intestine ("fore-gut"), the following parts, from the anterior to the posterior end, are recognized: Salivary glands—anterior evaginations, rudimentary or lacking in the Acrididae; esophagus; crop—an esophageal expansion; and gizzard ("proventriculus"), rudimentary in the Mantidae, almost vestigal in the Phasmidae, and vestigal or wanting in the Acrididae. The mid-intestine ("mid-gut," "ventriculus," "chylific stomach") consists of the enteric ("gastric," "pyloric") ceca—anterior evaginations, and the mid-intestine proper; the number of enteric ceca in the various families is as follows: Blattidae and Mantidae, eight; Phasmidae, none; Acrididae, six; and the Tettigoniidae, Gryllacrididae, Gryllidae, two—these being sac-like, while those of the other families are more tubular. The hind-intestine ("hind-gut") consists of the malpighian tubules—anterior evaginations variously grouped in the different families; small intestine—only in certain Blattidae; large intestine ("colon"); and the rectum—in many, little more than a colic expansion.

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Pyrethrum Flowers

Since the publication of the first edition of this book, a number of important facts concerning pyrethrum have been discovered and published in various journals. The author has reviewed all these papers and incorporated the new ideas in the recently published second edition. Three hundred eighty-seven references have been added to the bibliography. Many of the chapters have been enlarged, and some of these additions are recent work in isolation of pyrethrins, new chemical and biological methods of assaying pyrethrum products, additional information on livestock sprays, the decomposition of pyrethrum products in storage and the use of antioxidants to prevent the loss of toxic constituents, recent uses of pyrethrum as sprays and dusts, and the final chapter has been greatly enlarged and concerns the cultivation of pyrethrum in the United States. The book should be invaluable for teachers, students, and research workers in insecticide control.

—R. H. Davidson.

Pyrethrum Flowers, (Second Edition), by C. B. Gnadinger. xvi+371 pp., 41 pls., 12 figs. Minneapolis, McGill Lithograph Company, 1936.

MOHICAN FOREST PARK

KARL VER STEEG,
College of Wooster

One of Ohio's most scenic areas, unknown to many people, is located in southern Ashland County. It is easily accessible to tourists from any part of the State, as there are roads leading into the park from all sides. Recently a group of the Civilian Conservation Corps constructed roads, new trails and other features, greatly improving the area as well as making it more accessible.

The original part, an unorganized unit, contained 656 acres which were so located that the development of the area as a recreational center was all but impossible. Recently, enough land has been purchased and placed under option by the State to give the park an area of about 1,500 acres. Eventually it will contain approximately 2,100 acres. One of the dams proposed as part of the Muskingum Project (Pleasant Hill Dam) is being constructed in the Clear Fork gorge, at a point above the main area included within Mohican Forest Park.

The beauty of this park is not surpassed by any in Ohio unless it be the parks in Hocking County, in the southeastern part of the State. Mohican Forest Park lies, for the most part, within a heavily wooded, deep, narrow gorge, the valley of the Clear Fork, a tributary of Mohican River. Precipitous trails lead from the rim of the gorge down to the stream through a dense forest of hemlocks and pines with numerous hardwoods. The contrast in color is at all times beautiful, but especially so in the Fall when the hardwoods are in all their brilliance. According to R. R. Paton, Assistant State Forester, this forest contains the largest area of native white pine remaining in Ohio. Reforestation of the open areas has been progressing, pines being used almost entirely for this purpose.

If one enters the park from the south, he can obtain from the bluff of the gorge, the most spectacular view in the region. Here from a flat upland, one can look over a precipitous cliff, far down on the waters of the Clear Fork.

PHYSIOGRAPHY AND DRAINAGE CHANGES

The question which comes to one as he studies the region is why so deep and narrow a gorge is present here, when nothing

like it occurs in this section of Ohio. The answer lies in its physiographic history. A glance at the map shows that the valley of the Clear Fork narrows in the direction of flow and is narrowest at the position of the col in Mohican Forest Park, beyond which it widens, indicating that in preglacial and interglacial time, at the narrowest portion of the gorge, there was a

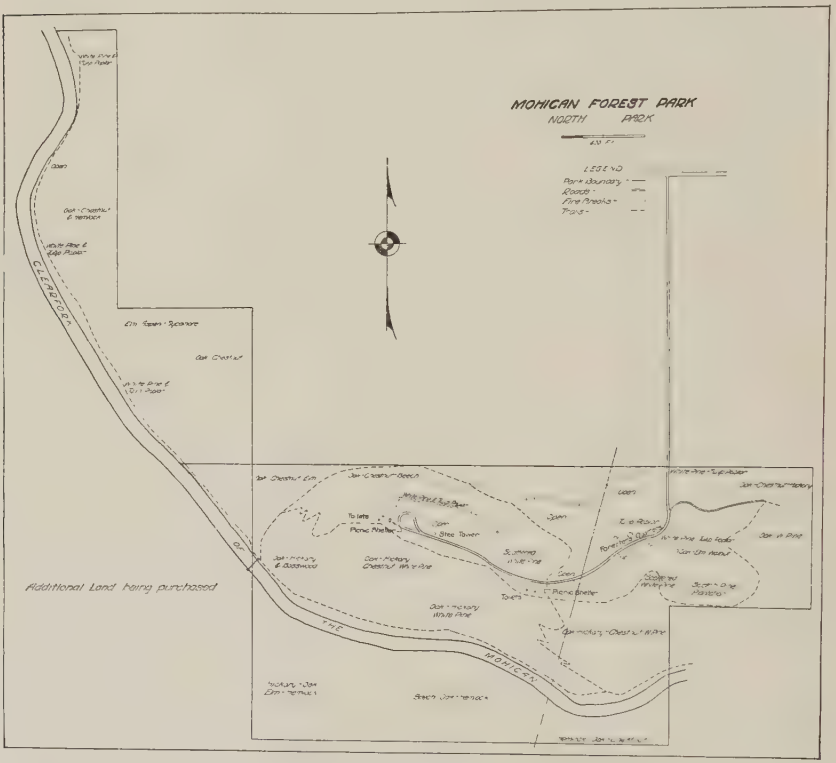

FIG. 1. Mohican Forest Park, north portion.

divide between two tributaries flowing in opposite directions. Due to the blocking of the drainage, the water was forced over the divide into Mohican River which flows south.

In an earlier paper[1] the present writer suggested that Clear Fork gorge might have had its origin as early as the

[1]Ver Steeg, Karl. Drainage Changes in the Vicinity of Loudonville, Ohio. Ohio Journal of Science, September, 1931, pp. 368–376.

Illinoian ice invasion. White[2] believes the diversion across the col occurred during the Wisconsin stage of glaciation and bases

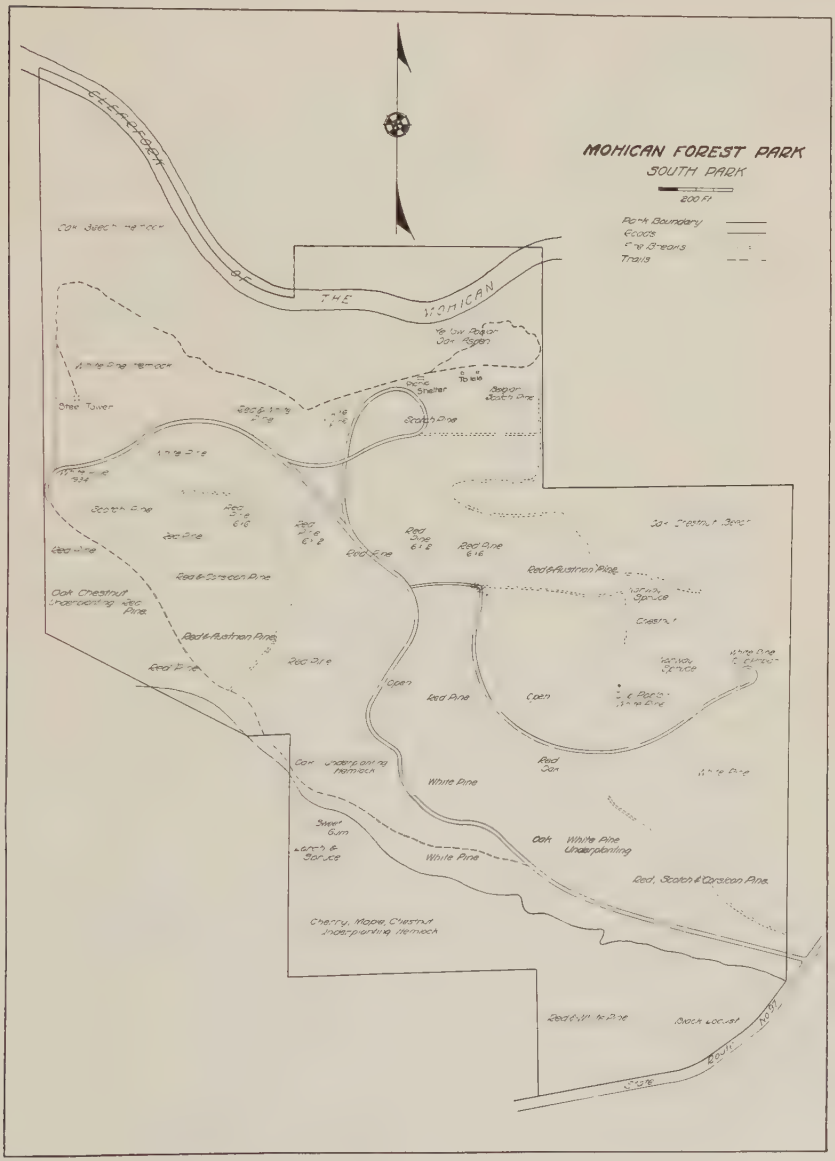

FIG. 2. Mohican Forest Park, south portion.

[2]White, George W. Drainage History of North-Central Ohio. Ohio Journal of Science, November, 1934, pp. 365–382.

his conclusions on the extreme narrowness of the col and its position immediately south of the Wisconsin glacial boundary. Although the present writer does not abandon the possibility that the diversion may have occurred during the Illinoian stage of glaciation, he believes that White's arguments have much in their favor and is willing to accept his interpretation as a basis for discussion.

It is now believed that the valleys in Ohio, in pre-Illinoian time, were deepened considerably during what is known as the Deep Stage. After the Kansan or pre-Kansan glaciation, during the Deep Stage, the Clear Fork occupied a deep, narrow valley. The tributaries flowing from the divide marked by the col, northwest to Clear Fork and east to Pine Creek, also occupied deep, narrow valleys during this time. If we accept White's interpretation, the Killbuck lobe of the Wisconsin ice-sheet advanced far enough south to dam the Clear Fork. The ponded waters at first found an outlet through the divide at the head of the valley of Smoky Run, southwest of Butler, and escaped into the valley of East Branch of Kokosing River near Ankenytown. This outlet was not used very long, for the Scioto lobe of the glacial advanced to the east of Ankenytown and far enough to the east of the outlet to close it. The ice of the border of the Killbuck lobe melted away from the old valley in northeastern Worthington Township so that the waters again followed the old course to the southwestern corner of Green Township. The edge of the ice prevented the water from entering the Black Fork valley and ponded it to a height sufficient to flow over the divide into the headwaters of a tributary of Pine Run, and eastward to the point where Pine Run and Black Fork meet. The chasm of the Clear Fork is the result of erosion during the Deep Stage, Wisconsin and postglacial time. The buried valleys[3] in north-central Ohio were deepened during this stage and compare in depth and narrowness with Clear Fork gorge. The extreme narrowness at the col in Mohican Forest Park is the result of recent postglacial erosion, probably rapid while silt-laden water from the Wisconsin ice-sheet passed over it. After the ice melted away the streams continued to flow as at present.

The Clear Creek gorge in Mohican Forest Park is an excellent example of a youthful valley. It is a quarter of a mile wide

[3]Ver Steeg, Karl. Buried Topography of North-Central Ohio. Journal of Geology, Volume XLII, No. 6, August-September, 1934, pp. 602–620.

across the top, tapering down to about 200 or 300 feet at the bottom. The characteristic features of youth are its V-shape,

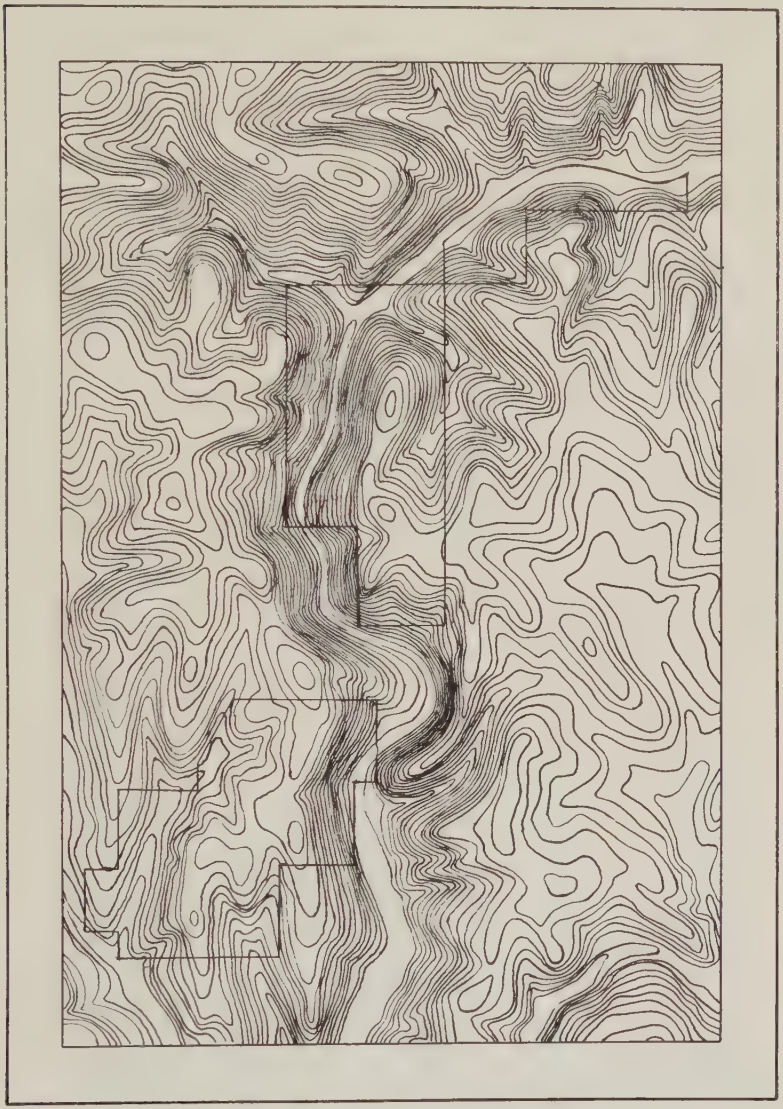

FIG. 3. Topographic Map of Mohican Forest Park, showing boundaries. (Contour interval—20 feet.)

steep sides with bold rock outcrops forming prominent cliffs, overlapping spurs, rapids, and the absence of a flood plain, indicating that the stream is actively cutting down its valley.

The presence of a massive sandstone formation, a hundred or more feet thick, which forms the rim of the gorge, is largely responsible for its narrowness. This resistant formation has prevented the rapid widening of the valley by weathering and erosion, retaining the narrow, gorge-like character for a longer period of time. Furthermore, the short period of time, from the Wisconsin to the present, has not been sufficiently long to enable the erosive agents to widen the valley and reduce its slopes to a lower angle of inclination. The youthful appearance of the valley is in harmony with the fact that a divide existed here in preglacial and possibly interglacial time, through which has been cut the postglacial gorge.

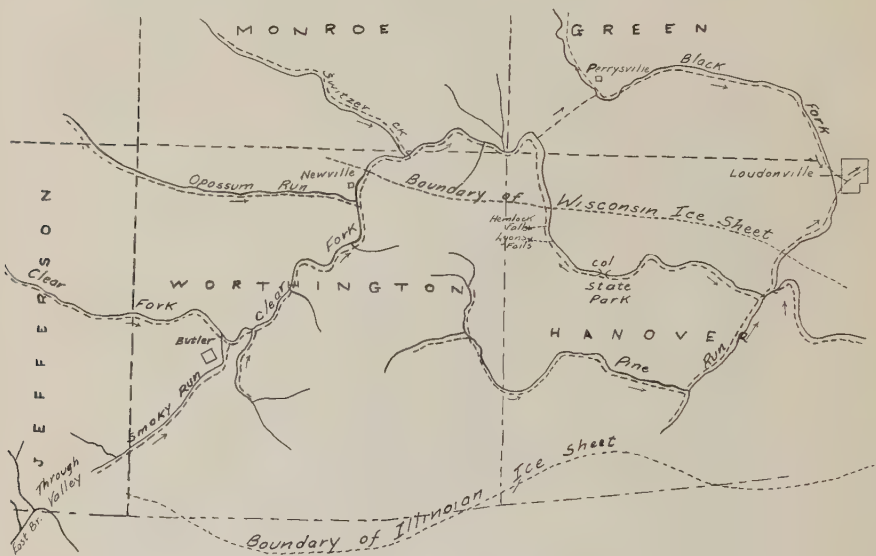

FIG. 4. Interglacial and present drainage lines of Mohican Forest Park region.

One of the most attractive spots is Lyons Falls. Here, at the head of a narrow ravine, leading to the Clear Fork, the water dashes from the upland over a forty-foot cliff which has been undermined, giving it the form of an amphitheatre. This cave, if it may be so called, resembles Ash Cave in the Hocking County area, except that the latter is much larger. It is evident that the combined weathering of the sandstone and pot-hole action are responsible for the undermining of the cliff. The undercutting or sapping process has been the cause of the recession of the falls. The narrow gorge with its overhanging

FIG. 5. Aerial photograph of Mohican Forest Park and surrounding territory.
(Loaned by Fred L. Smith, director, Ohio Bureau of Aeronautics.)

FIG. 6. Two views of Clear Fork Gorge.

cliff at its head, is similar to many of the glens cut in massive sandstone formations in other parts of the country. Hemlock Falls, beyond the ridge north of Lyons Falls, and located on another tributary of the Clear Fork, is smaller, but illustrates the processes of recession better than at the larger falls. Here large masses of sandstone have toppled from the semicircular, overhanging cliff which has a pot-hole at its base.

GEOLOGICAL FORMATIONS

The rock formations which outcrop in Clear Fork gorge belong to the Waverly series and were laid down in Lower Mississippian time. Two members of the Waverly series, the Cuyahoga and Logan formations, make up the succession of beds exposed in the gorge. Only a part of the Cuyahoga formation is exposed; the valley floor is cut in it and it extends well up the sides of the valley. The Logan formation which overlies the Cuyahoga is composed chiefly of sandstone, whereas a larger proportion of shale makes up the Cuyahoga. The Clear Fork flows over beds which are composed, for the most part of shale, with thin sandstone layers interstratified. With the exception of a few thin beds of conglomerate, the entire succession of beds is sandstone and shale, the total amount of sandstone exceeding the shale in thickness. The high cliffs which form the rim of the gorge and add so much to the scenery of the park, are composed of the thick-bedded sandstones of the Logan formation.

A section of the rock formation in the gorge, from the stream level to the rim and beyond to the upland, are approximately as follows: Up to about 55 feet above the level of the stream, thin beds of sandstone make up the series. About 30 feet of sandstone with shale horizons follows. There appears at approximately 80 to 85 feet above the stream, a bed of conglomerate about one foot thick. This stratum is composed of pebbles about as large as a pea, cemented by iron oxide. It is a persistent formation and is the source of water in the region which it underlies. Above the conglomerate lies about 10 feet of thick-bedded sandstone, upon which rests a thick succession of slabby sandstone interstratified with occasional strata of shale, the whole approximately 140 feet thick. Above this and extending up to the rim of the gorge is a thick succession of sandstone beds, constituting the main part of the Logan formation.

FLORA

The following description of the flora of Mohican Forest Park was supplied by Assistant State Forester R. R. Paton, of the Ohio Agricultural Experiment Station.

The forest in the valley of the Clear Fork, in the area enclosed by Mohican Park, varies widely in its composition, due largely to the depth of the gorge. The adjacent highland is farm land, reaching to the summit of the valley slopes. The native forest of the gorge has encroached on the adjacent farm land in places. This volunteer growth, or old field type, is composed of staghorn, sumach, pignut, mockernut, shellbark hickories, white pine (where seed trees are present), large tooth aspen, hawthorn, sassafras, black cherry, red maple and an occasional red cedar.

The forest in the valley changes as it progresses from the top of the valley wall or ridge type, through the upper slope, middle slope, and lower slope to the bottoms, and the south wall is characteristically different from the north wall. The ridge forest on both sides is essentially the same and is composed of white, red, scarlet, black and chestnut oaks, red maple, the hickories, an occasional white pine and formerly chestnut. On the south wall, down from the ridge to the upper slope, hemlock, beech, hard maple, black cherry, occasional yellow poplars, white ashes and ironwoods (*Ostrya Virginiana*) come into the forest composition. The hemlock begins at the top of the valley wall, while the chestnut oaks become noticeably fewer in number within a short distance below the ridge. The middle slope forest is denser, the beech, yellow poplar and white ash are more numerous, shad bush appears and the hickories become less numerous. The lower slope forest is still denser with a great variety of species. The hemlock is common, in places being the predominant tree; the beech, hard maple, yellow poplar, white ash and shad bush are more common and butternut, black walnut, basswood, white red elms, black alder, blue beech, Canadian yew, pawpaw, mountain maple (*Acer Spicatum*), witch hazel, spice bush and an occasional yellow birth is found. This is a typical northern beech, maple, hemlock forest, with species occurring here which are rare in Ohio, namely, hemlock, yew, mountain maple and yellow birch. The hickories and oaks are present but not numerous. In the bottoms, sycamore, willows, buckeye (*Resculus Glabra*), haw-

thorn, bladdernut and dogwood are found near the stream. The north slope of the gorge is similar to the south side on the middle and upper slopes except for the substitution of white pine for the hemlock. The lower slopes have a higher percentage of oaks, fewer yellow poplars, hard maples and beech and no Canadian yew, mountain maple, black ash or yellow birch.

Bailey's Histology

This well known text was thoroughly revised and greatly improved in the seventh and eighth editions. The present (ninth) edition conforms in organization and style to the last edition and is the work of five collaborators, all members of the Anatomy Department of the College of Physicians and Surgeons, Columbia University. Four chapters have been rewritten and most of the others have been reorganized or revised to incorporate new material. The book is well balanced and the organization is logical. The cell is first considered as a structural and functional unit, attention being directed both to fixed preparations and the living cell as seen in tissue culture and other preparations. Then the various tissues are described and finally the several systems with their respective structures and organs. In each section the histogenesis of the particular tissues is briefly given. In many instances the life cycle and ultimate fate of special cells are indicated. Occasional references are made to gross anatomical relationships to facilitate orientation and the more frequent use of such references would probably be welcomed by the average student. At the outset the authors recognize that structure assumes its fullest significance only when it is correlated with function and this thesis is carried throughout the text. Certainly this is good pedagogy for memory rests upon interest and association and the student will remember structure to the degree that he is able to interpret it in terms of life processes. This text may be confidently recommended for teaching purposes as a clear and straight-forward treatment of the subject.—O. C. Woolpert.

Bailey's Textbook of Histology, by various authors. Ninth edition. xvi+ 773 pp. Baltimore, William Wood & Co., 1936. $6.00.

Gems

A student who takes geology sooner or later comes to his instructor with a question concerning gems. Usually the instructor refers him to some trade article or else perforce to some technical and specialized report on one or at the most two kinds of gems. This new book on gems has as a subtitle "A Popular Handbook." It more than justifies the name. The first four chapters discuss the ancient use of gems and the development of the art and styles of cutting them. The diamond is taken up first, followed by a brief discussion of famous diamonds. Other precious stones are discussed, followed by accounts of semiprecious stones. Then is discussed chrysoberyl, opal, quartz gems, opaque gems, and unusual gems such as anatase, andalusite, benitoite, cassiterite, cyanite, hematite. Organic gems such as pearls and amber are discussed in chapter 16. A general bibliography is followed by a six-page descriptive table of gems. This table gives in a concise manner the name, mineral composition, color, transparency, hardness, specific gravity, occurrence, and usual cutting methods.

This book fills a long felt want. It is well and interestingly written, the style is smooth and it holds the interest. The illustrations are excellent and so placed as to greatly enhance the text.—Willard Berry.

The Study of Gems, by Herbert P. Whitlock. 206 pages. New York, Lee Furman, Inc., 1936.

TWO HEMIPTEROUS ENEMIES OF THE MEXICAN BEAN BEETLE IN OHIO[1]

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AND
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Since the World War the Mexican bean beetle, *Epilachna corrupta* Muls., has been a serious pest of beans in Eastern United States. A number of native parasites and predators of the beetle have been reported by Howard and English ('24) and Howard ('30). Quantitative data are not given for any of the predators and parasites. It may be of interest to record a little quantitative data regarding two predators, one of which has not been recorded as a predator of the bean beetle previously.

On July 21, 1933, the senior author found a female of the pentatomid bug, *Perillus circumcinctus* Stål, feeding on an adult Mexican bean beetle. The pentatomid was placed in a cage with a bean plant and each morning ten adult bean beetles not over two days old were placed in the cage. All beetles were removed from the cage each day and the numbers killed by the pentatomid recorded. For the first week a control cage with the same number of beetles was observed. In eight days only one dead beetle was found so the control was discontinued since it was evident that the natural death rate among the young beetles was very low.

The maximum number of beetles killed on any one day was five and the minimum number one. A total of 85 bean beetles were fed upon in 27 days of observation. This is an average of 3.15 beetles per day. *Perillus circumcinctus* Stål has not previously been recorded as a predator on Mexican bean beetle.

On July 7, 1935, the junior author (W. F.) found a nymph of the reduviid, *Arilus cristatus* (Linn.) feeding on Mexican bean beetles. This nymph was placed in a cage with a bean plant and both adult and large larval bean beetles were introduced daily. The full data for this nymph are given since they show so clearly the influence of moulting on the feeding habits of this reduviid.

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[1]Paper No. 11, Department of Biology, Ohio University, Athens, Ohio.

Reduction of feeding began on July 9 and 10, and on July 11 and 12 no food was taken. On July 13 the last nymphal moult occurred. On the day following no food was taken and on the next three days only larvae were attacked. On July 18 the adult beetles were again attacked and formed the bulk of the food until August 1. On August 2 no food was taken and on August 3 the insect moulted again and became an adult. During 28 days it had consumed 69 adult beetles and 22 large larvae, thus accounting for 91 beetles altogether. This is an average of 3.25 beetles per day.

TABLE I

Mexican Bean Beetle Adults and Larvae Fed upon by *Arilus cristatus* (Linn.) During Period of Observation

DATE	FOOD		DATE	FOOD		DATE	FOOD	
	Adults	Larvae		Adults	Larvae		Adults	Larvae
July 7	5	4	July 17	0	1	July 27	2	2
July 8	4	2	July 18	3	2	July 28	3	0
July 9	3	0	July 19	2	2	July 29	4	0
July 10	2	0	July 20	3	1	July 30	3	1
July 11	0	0	July 21	4	0	July 31	2	1
July 12	0	0	July 22	2	0	Aug. 1	4	0
July 13	0	0	July 23	5	0	Aug. 2	0	0
Moult	Last N	ymphal	July 24	6	2	Aug. 3	0	0
July 14	0	0	July 25	8	0	Moult,	to adult	
July 15	0	2	July 26	4	0	Observa	tion	
July 16	0	2				discon	tinued.	

Arilus cristatus is more common in Southeastern Ohio than *Perillus circumcinctus*, but neither is present in large enough numbers to be effective as a natural control. This is in accord with previous reports of natural enemies of the Mexican bean beetle in Eastern United States. From the standpoint of the biology of these species it is of interest, however, to record their capabilities.

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STUDIES OF THE GENUS SCAPHOIDEUS (HOMOPTERA, CICADELLIDAE)

Part II. Nine New North American Species and Descriptions of Five Male Allotypes

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AND
LAWRENCE BEERY,
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In a recent paper[1] (Part I) the genus was discussed and seventeen new species were described on the basis of the internal male genital characters. The present discussion is a continuation of this study using the internal male structures to establish several species already described, from females only, by Professor Herbert Osborn. The allotypes of these species are placed with the types in the Osborn Collection. Several species are described also which belong to the *productus-carinatus* group and which have previously been confused with these two species.

Scaphoideus veterator n. sp.

Resembling *frisoni* in form and general appearance but paler in color and with distinct genitalia. Length, 6–7 mm.

Vertex strongly produced and sharply angled, a little longer at middle than basal width between eyes.

Color: Face pale brown with at least two dark arcs above. The dark line just beneath margin of vertex and the one just above interrupted at middle. Vertex pale, median transverse band reddish brown, central portion darker. Pronotum brown with a paler transverse band behind eyes. Scutellum brown, the apical half white. Elytra white tinged with brown, veins dark brown.

Genitalia: Female last ventral segment with posterior margin roundedly produced, the apex slightly notched. Male plates longer than combined basal width, broad at base concavely narrowed on apical third to form blunt, pointed apices. Styles broad at base, concavely, abruptly, narrowed to form slender, pointed caudally directed apical third. Oedagus in ventral view with a pair of long processes arising near base slightly constricted at about one-third their length, beyond which they are broadened and gradually tapered to long slender pointed apices. These two processes cross so that the apical fourth is directed laterally. Dorsal process in lateral view with

[1]Amer. Mid. Naturalist. 17: 965, November, 1936.

apical portion rather long, curved caudally, apex blunt, rounded, a slight tooth on dorsal edge.

Described from one male and three female specimens collected at Loyalsock, Pa., August 12, 1918, by J. G. Sanders; one male, Cedar Run, Pa., July 12, 1920, J. N. Knull; one female, Port Trevoiton, July 26, 1918, J. G. Sanders. Holotype male and allotype female (Loyalsock, Pa.) and male and female paratypes in collection of senior author.

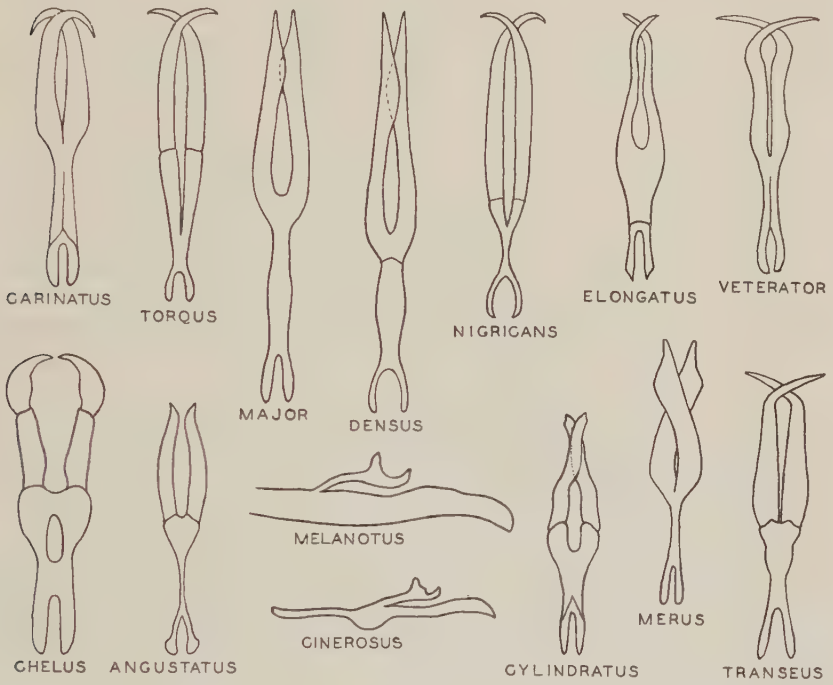

FIG. 1. Ventral views of male oedagi as labeled except in cases of melanotus and cinerosus which are lateral views.

This species differs from *transeus* in having more bluntly pointed plates and by having a dorsally produced portion on the connective. It differs from *frisoni* which has a more constricted portion in oedagus, blunter pointed plates, longer slender curved tips of styles and a tooth on lower caudal portion of pygofer.

Scaphoideus angustatus n. sp.

Resembling *frisoni* in form and appearance but with distinct genitalia. Length, 6 mm.

Vertex strongly produced and bluntly angled, a little wider between eyes at base than median length.

Color: Face pale with two heavy arcs above. The general coloration is essentially like *veterator*. The transverse band on disc of vertex strongly produced anteriorly at middle. Elytra rather pale brown, veins darker.

Genitalia: Male plates not quite as long as combined width at base, broad at base, convexly rounded then narrowed to blunt, pointed apices. Styles abruptly narrowed at two-thirds their length to form long, narrow processes which are curved slightly outwardly. Oedagus in ventral view with a pair of long processes arising near base and extending caudally. These are dorso-ventrally flattened, curved inwardly at apices and are separated at middle. The pointed apices are formed by the curvature of the inner margin as it meets the outer margin. Dorsal process extending ventrally between the two ventral processes of oedagus.

Described from two male specimens collected in Pennsylvania. One was collected at Ohio Pyle, July 20, 1919 (D. M. DeLong); and the other at Speeceville, July 3, 1917, by J. G. Sanders. Holotype male, Speeceville, Pa., and paratype male in collection of senior author.

This species can be distinguished from *merus* which it most closely resembles by the more narrow processes of the oedagus, by having the plates more pointed at apex, the apices of styles more slender and straight, and the apical portion of the dorsal process more narrow and without a dorsal tooth at the apex.

Scaphoideus merus n. sp.

Resembling *carinatus* in size, form and general appearance, but with distinct genitalia. Length, 6.5–7 mm.

Vertex strongly produced, apex bluntly angled, almost as long at middle as basal width between the eyes.

Color: Face pale with two heavy dark bands below margin of vertex. Marginal line above, broken at middle and widened either side at apex. Median transverse band on vertex decidedly notched either side of central anterior produced portion, causing it to appear trilobate anteriorly. Pronotum and scutellum dark brown, mottled.. Elytra white, washed with pale brown, veins, margin at apex and a spot on center of clavus dark brown.

Genitalia: Female last ventral segment with prominent lateral angles, posterior margin almost truncate, slightly emarginate either side of middle and black margined. Male plates short and broad, length equalling combined basal width, convexly rounded to form blunt apices, styles abruptly narrowed at two-thirds their length to form narrow processes which are bent strongly outwardly and produced. Oedagus in ventral view with a pair of short broad, flat processes arising near the base, curved so as to leave an opening between them at base but overlapping at apex. The inner margin curves and slopes to outer margin so as to form a pointed apex. Dorsal process with the apical portion rather broad, rounded at apex and with a dorsal pointed tooth.

Described from a series of four female and seven male specimens collected at Washington, D. C., July 3, 1919, (Sanders); two females, Ohio Pyle, Penna., July 19, 1919, (DeLong); one female, Charter Oak,

Penna., (Kirk and Champlain); one male, Port Trevoiton, Penna., July 26, 1918, (Sanders); one male, N. Bloomfield, Penna., July 26, 1920, (Sanders); one male, Richfield, Penna., July 16, 1918, (Sanders); one male, Chambersburg, Penna., June 14, (Knull).

Holotype male, allotype female (Washington, D. C.) and male and female paratypes in collection of senior author. Male and female paratype in Illinois Natural History Survey Collection, Urbana, Illinois.

Scaphoideus torqus n. sp.

Resembling *major* in general appearance, but with distinct genitalia. Length, 6.5 mm.

Vertex strongly angled, apex blunt, almost as long at middle as basal width between eyes.

Color: Face pale brownish with at least three heavy brown arcs above. Brown line below vertex margin heavy, the one above more narrow and interrupted at middle. Vertex pale, band on disc rather narrow and slightly produced anteriorly at middle. Pronotum and scutellum tawny. Elytra pale, veins brown, darker on posterior half.

Genitalia: Male plates about as long as combined basal width tapered to bluntly pointed apices. Basal two-thirds of styles broad, apices narrow, long and gently curving outwardly at tips. Oedagus in ventral view composed of two portions which are separated at base but curve inwardly and cross anterior to the apices which are directed laterally. The dorsal process with apical portion tapered, bluntly pointed and not bearing a dorsal tooth. The upper apical portion of pygofer with a distinct tooth which will readily separate this species from those closely related.

Described from three male specimens, one collected at North East, Pa., July 30, 1919, (D. M. DeLong); one at Harrisburg, Pa., July 7, 1918, (J. G. Sanders); one at Castle Rock, Grand Detour, Ill., July 2, 1932, (Dozier and Mohr). Holotype male, North East, Pa., and male paratype in collection of senior author. Male paratype in State Natural History Survey Collection, Urbana, Illinois.

Scaphoideus elongatus n. sp.

Resembling *cirrus* in form and appearance but with distinct genitalia. Length, 6.5–7 mm.

Vertex strongly angled, apex blunt, slightly wider between eyes at base than median length.

Color: Face pale, slightly smoky with dark arcs above. A slender black line just beneath margin of vertex, the one above a little broader either side of median line where it is broken. Median transverse band on disc of vertex rather narrow, tawny and strongly produced anteriorly at middle. Pronotum and scutellum brownish mottled with white. Apical half of scutellum paler. Elytra white, veins dark brown, fuscous blotches forming an indefinite oblique band from anterior claval area to median costal area. Apices smoky.

Genitalia: Female last ventral segment almost truncate, slightly produced, and slightly concavely rounded at middle. Male plates

longer than combined width at base, gradually narrowed to pointed apices. Styles very broad at base, abruptly narrowed at about half their length to form long slightly curved tapering apices. Oedagus in ventral view composed of a pair of processes which taper to pointed apices and which overlap. These are curved so as to be contiguous at middle and be separated anterior to and posterior to this point. The pygofer is unusually long and pointed. This alone will separate the species from all others except *chelus*, which has a very different oedagus.

Described from two male and one female specimens collected at Waynesburg, Pa., July 16, 1919, by the senior author; and four female specimens, one each from Anacostia, D. C., August 22, 1905, (J. G. Sanders); Chain Bridge, Va., August 13, 1905, (J. G. Sanders); Greenfield, Pa., August 28, 1920, (D. M. DeLong); Tupelo, Miss., July 1, 1921, (C. J. Drake); and Starved Rock, Illinois, July 14, 1932, (Dozier and Park). Male holotype, female allotype (Waynesburg, Pa.) and male and female paratypes in collection of senior author. Male paratype is in State Natural History Survey collection, Urbana, Illinois.

Scaphoideus cylindratus n. sp.

Resembling *frisoni* in general appearance but with blunter head, darker color and distinct genitalia. Length, 6–6.5 mm.

Vertex rather strongly angled, blunt at apex, about as long at middle as basal width between eyes.

Color: Face pale brown with broken arcs and two continuous dark lines beneath margin of vertex. Marginal line above slightly broken at middle. Vertex pale, transverse band on vertex narrow, slightly produced at middle and pale orange in color. Pronotum uniform brown, scutellum paler with basal angles dark. Elytra rather uniform dull brown in color with veins and apex darker but almost devoid of areolar markings.

Genitalia: Female last ventral segment broadly roundedly produced and black margined on central half. Male plates almost one-third longer than combined width at base, convexly rounded and tapered to pointed apices. Apical third of styles composed of long, slender, tapering processes. Oedagus in ventral view composed of a pair of rather short, broad cylindrical processes which are bluntly pointed and slightly curved upwards at apex. Dorsal process rather long, apical portion slender and tapered to blunt tip.

Described from a series of six female and one male specimens collected at Kane, Pa., August 18, 1921, and 22, 1919, (D. M. DeLong); male, Loyalsock, Pa., August 2, 1918, (J. G. Sanders); male, Ft. Kent, Maine, August 28, 1910, (Herbert Osborn); Ithaca, N. Y., August 1, 1905; Urbana, Ill., July 2, 1920, (C. P. Alexander). Holotype male, Loyalsock, Pa., allotype female, Kane, Pa., and male and female paratypes in senior author's collection. Paratype male (Urbana, Ill.), Illinois State Natural History Survey collection, Urbana, Illinois.

Scaphoideus chelus n. sp.

Resembling *major* in form and general appearance but darker and with distinct genitalia. Length, 6–7 mm.

Vertex rather sharply angled, median length equalling basal width between eyes.

Color: Face slightly tawny with one broad and several narrow arcs above. A dark line just below vertex and a slender one above, broken at middle. Vertex pale with a rather broad and somewhat poorly defined transverse band between eyes, tawny. Pronotum and scutellum brown, the former with a paler indistinct band. Elytra brownish, veins dark brown.

Genitalia: Female last ventral segment with prominent angles, posterior margin slightly produced to form a median rounded lobe which is slightly emarginate at apex. Male plates rather short and broad, a little longer than combined basal width, convexly rounded to blunt apices. Styles with apical third narrow, tapering to pointed apex and curved slightly outwardly. Oedagus in ventral view with a pair of separated processes arising from basal portion which extend caudally and bear at their apices a pair of curved, broad, pincher-like processes which taper to sharp pointed proximal apices. Dorsal process with a rather long tapering apical process which curves slightly upward and is bluntly pointed at apex.

Described from a male and two female specimens collected at Dolson (Rocky Branch) Illinois, July 18, 1934, by H. H. Ross and the senior author, and one male specimen from Alton, Illinois, June 27, 1934, by the same collectors. Holotype male and allotype female (Dolson) in State Natural History Survey collection, Urbana, Illinois. Male and female paratype in collection of senior author.

Scaphoideus transeus n. sp.

Resembling *major* in form and general appearance but with distinct genitalia. Length, 5.5 mm.

Vertex strongly produced and bluntly angled, median length equaling basal width.

Color: Face pale, a narrow black line beneath the margin of vertex and a broader one ventral to this. Marginal line above broken at middle and broadened either side of apex. Vertex white, transverse median band orange at sides darker at middle and anteriorly produced. Pronotum and scutellum pale brown, veins, apex and spot on median costa dark brown.

Genitalia: Female last ventral segment with posterior margin slightly produced, median fourth with a rather broad, shallow notch. Male plates longer than combined basal width, narrowed almost from base to form long pointed tips with blunt apices. Apical half of styles narrow, tapered to pointed apices and almost straight. Oedagus in ventral view composed of a pair of processes which are broad and proximal at base and which diverge to apex of plates where they bend inwardly, cross and taper to long pointed apices. Dorsal process of oedagus with a rather long curved rather narrow apical portion.

Described from a male and female collected at Dolson, Illinois (Rocky Branch), July 18, 1934, (Ross and DeLong); one male, Galena, Illinois, July 10, 1934 (Ross and DeLong); one male, Ames, Iowa, June 22, 1896, (Herbert Osborn); one male, Washington, D. C., without date. Holotype male, Ames, Iowa, in Herbert Osborn collection. Allotype female and paratype males from Illinois in State Natural History Survey collection, Urbana, Illinois. Male paratype, Washington, D. C., in senior author's collection.

Scaphoideus densus n. sp.

Resembling *major* in form and general appearance but smaller and with distinct genitalia. Length, 6–6.5 mm.

Vertex strongly produced and angled, a little wider between eyes than median length.

Color: Face pale with three dark lines on upper portion. Marginal line on vertex broken at middle and broadened either side. Median band narrow, obliquely sloping to margin on either side and strongly produced at middle, tawny. Pronotum and scutellum brownish, elytra white, washed with pale brown, a spot on anterior clavus and apex of elytra dark brown.

Genitalia: Female last ventral segment slightly produced, rounded and broadly black margined. Male plates about as long as combined basal width, apical half sloping to bluntly pointed apices. Styles broad, convexly, roundedly constricted and notched at two-thirds their length forming rather long, outwardly curved, bluntly pointed apices. Oedagus more than one-third longer than connective, two branched, each arm broadened on inner margin one-third the distance from apex and tapered to a sharp pointed tip. In lateral view the oedagus is broadened near apex, curved and tapered to pointed tip. Dorsal process very broad at base with a short thick apical portion which is rounded at apex and bears a dorsal spine.

Described from a series of two male and two female specimens collected at Elizabethtown, Illinois, May 27, 1931, and June 25, 1932, by Ross, Dozier and Park; one male, Bluff Springs, Illinois, June 10, 1932, Ross and Mohr; one male, Eichorn, Illinois, June 13, 1934, Ross and DeLong; one male, Little Mt., Ohio, August 21, 1904, (Osborn collection); and one male, Rigaud, Quebec, August 4, J. O. Quellet.

Holotype male (Rigaud, Quebec) in author's collection. Allotype female and male and female paratypes in Illinois State Natural History Survey collection, Urbana, Illinois. Paratype male in Herbert Osborn collection.

Scaphoideus cinerosus Osborn

Scaphoideus cinerosus Osborn. Jour. Cinc. Soc. Nat. Hist. 19: 208, 1900.

Male plates rather short, broadly rounded at apex. Styles broad at base, tapered to slender, outwardly bent and pointed apices. Oedagus in ventral view appearing two-branched with processes long, straight and tapered to pointed apices. In lateral view enlarged at about one-half its length then constricted with the apical third broadened apex

curved on dorsal portion to a ventral sharp pointed tip. Dorsal process arising from enlarged process at middle, expanded at apex with a blunt rounded anterior process, a curved finger process caudally and a median dorsal tooth.

Allotype male, Granville, Ohio, July 25, 1928, in Herbert Osborn collection.

Scaphoideus nigricans Osborn

Scaphoideus nigricans Osborn. Ohio Nat. 11: 258, 1910.

Male plates as long as combined basal width, tapered from base to bluntly pointed apices. Styles long, concavely narrowed at about one-third their length and again near the apex so that the terminal fourth is produced into a slender curved finger-like process. Oedagus two-branched, processes long, curved inwardly, crossed near apex and tapered to pointed tips. In lateral view with processes curved upwardly and anteriorly at apex. The dorsal process long, broad at base, rather abruptly narrowed and produced into a long, caudally directed, bluntly pointed process.

Allotype male, Black Mt., N. C., June, in Herbert Osborn collection, Ohio State University.

Scaphoideus melanotus Osborn

Scaphoideus melanotus Osborn. Jour. Cinc. Soc. Nat. Hist. 19:206, 1900.

Male plates one-fourth longer than combined basal width, scarcely narrowed toward apices which are broadly rounded. Styles suddenly narrowed, apical fourth long, slender, strongly curved outwardly. Oedagus in lateral view broad, apex broadly, bluntly rounded. Dorsal process rather slender at base, broader apically, forming two short divergent processes. Pygofers with a pair of spines at apex which are large and turned inwardly.

Allotype male, Ames, Iowa, 7–30–96, in Herbert Osborn collection, Ohio State University.

Scaphoideus productus Osborn

Scaphoideus productus Osborn. Jour. Cinc. Soc. Nat. Hist. 19:200, 1900.

In the Osborn collection is a series of four cotypes, all females, two of which are undoubtedly the same species and have the strongly produced female segment described by Professor Osborn in the original description. Since it seems necessary to choose a lectotype at this time the specimen labeled "Experiment Station, Ames, Iowa, Aug. 7, 97" is designated. It has been impossible to choose a male allotype because all those which are similar in form and color have been definitely associated with female specimens which do not have the strongly produced segment.

Scaphoideus major Osborn

Scaphoideus immistus var. *major* Osborn, Jour. Cinc. Soc. Nat. Hist., 19:205, 1900.

The type of this species described by Professor Osborn is labeled "Ames, Iowa, 7–30–96." The male allotype is labeled "Ames, Iowa,

6–27–96." Both are in the Osborn collection. The internal genitalia have not been described.

Male plates not quite as long as combined basal width strongly convexly rounded to bluntly pointed apices. Styles tapered from base, strongly and suddenly narrowed on outer margin so that the apical fifth is a short outwardly curved finger-like process. Oedagus about the length of the connective, two-branched, in ventral view appearing broadened on inner margins about one-third the distance from apex and tapered to pointed tips. In lateral view the oedagus is tapered to a long attenuated pointed apex. Dorsal process semicircular, tapered to apex which is blunt, slightly enlarged and with a very small dorsal spine.

Scaphoideus carinatus Osborn

Scaphoideus carinatus Osborn. Jour. Cinc. Soc. Nat. Hist. 19:201, 1900.

Two female cotypes are in the Osborn collection. The specimen labeled Hanover, N. H., C. M. Weed is designated as the lectotype. A series of five female and one male specimens are in the Osborn collection labeled Little Mt., Ohio, Aug. 21, 1904. These are females agreeing exactly with the type and the corresponding male is here described and designated as the allotype.

Male plates about as long as combined width at base, sloping gradually from base to near apices where they are abruptly narrowed on outer margins, then produced to sharp pointed apices. Inner margins of plates curved outwardly at apex. Styles broad at base, abruptly narrowed near apex to form short finger-like processes which are curved outwardly at apices. Connectives long, reaching two-thirds the length of plates and with dorsal structures which are broad and vertical. Oedagus in ventral view two-branched, processes short and thick, usually crossed and curving caudally and dorsally into segment. The dorsal process is short and thick, usually lying in the concavity of the curved oedagus processes.

Allotype male, Little Mt., Ohio, Aug. 21, 1904, in Herbert Osborn collection, Ohio State University.

Biochemistry

This concise textbook on biochemistry is not offered as a substitute for, nor is it a condensation of, the author's well known textbook of Physiological Chemistry. It is written for the medical student who must cover the subject in a limited time and yet not miss any of the fundamentals. The text is based on the author's long teaching experience. It progresses logically and easily and gives a digest of established facts without going into speculative fields. The many structural formulae are clearly printed and some of the chapters dealing with broadly complex material are followed by summaries. Newer subject matter is given as from the particular worker in that field, but there is no compilation of a reference bibliography. The book has a good working index.—R. G. Schott.

Principles of Biochemistry, by Albert P. Mathews. x+512 pp. Baltimore, William Wood and Co., 1936. $4.50.

STUDIES IN THE BIOLOGY OF THE LEECH. IV

An Explanation of Certain Phases of Leech Behavior

JOHN A. MILLER,
Ohio State University

In the study of natural phenomena man is confronted with a three-fold problem. First, what occurs; second, how does it occur; third, how can one account for its occurrence. In answering the first two of these questions it is only necessary to make careful observations and to give accurate descriptions of the phenomena. The solution to the third, however, enjoys the distinction of being the product of careful analysis of causal factors and the application of established principles. The study of animal behavior not only involves an analysis of the action systems and the responses of the organism, but it demands a physical explanation of these responses.

I regard the knowledge of the nervous and muscular systems essential to an understanding and explanation of the behavior of any animal. Each species has its characteristic mode of reaction to changes in its environment. Its behavior is determined primarily by the nature of the behavior pattern which is a recognized part of its inherited organization. The morphology of the nervous and muscular system of the leech *Haemopis marmoratis* has been previously described, so that for the purposes of this paper we do not need to deal with it further.

Through a knowledge of the nervous and muscular system, and through the treatment of this behavior pattern as a basis, we are able to describe and explain certain phases of leech (*Haemopis marmoratis* (Say)) behavior. It is the object of this paper to interpret certain characteristic movements in terms of the stimuli and the intrinsic behavior patterns.

Discussion of Responses to Electrical Stimulation

The behavior of an animal consists of acts which are the ultimate effects of stimuli upon its particular type of anatomical structures. These stimuli originate either from the environmental forces of the outer world or from causes operating within the body of the animal. The usual reactions to external stimuli are movements.

As described in preceding publications (Miller, '33–'34) there are distinct differences in behavior when the leech is subjected to different stimuli. These differences in behavior are due to the contraction of different combinations of body wall muscles. These muscles contract only upon stimulation. Direct current of low voltage stimulates motor neurons directly. (Loeb, Lillie, Shensa and Barrows).

Shensa and Barrows (1932) applied the "Law of Polar Stimulation," Lillie (1923) to the neurons of the subepidermal nerve plexus in the earthworm. In so doing they explained the behavior of the worm to lateral electrical stimulation.

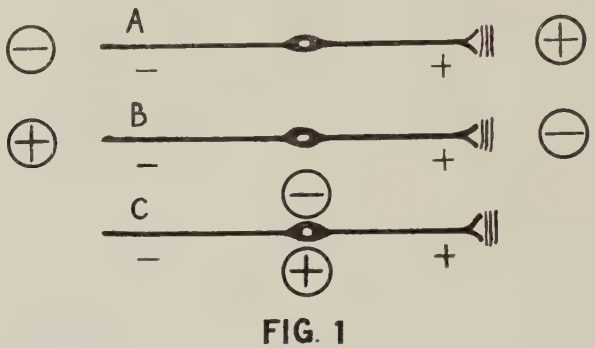

FIG. 1. Diagram illustrating the arrangement of electrodes in relation to the nerve cells and muscles. The electrodes are shown inside circles. A, the current direction which causes muscular contraction; B, the current direction which causes muscular relaxation; C, the current direction which does not affect the polarity of the neuron.

Experimental evidence, obtained by the author, demonstrates the same polarity of motor neurons in the leech. The references to galvanotropic responses on the part of some of the Annelida is to be found in the literature. The use, however, of this law or principle directed to a better understanding of the minute nervous structure and behavior of the leech has not previously appeared in the literature.

ANTERIOR POSTERIOR STIMULATION

Figure 1 illustrates neuron polarity and the effect upon the muscle of electrodes placed in a variety of relations to the neuron. It has been previously stated (Miller, '34) that when the negative electrode is placed in front of the anterior end of the leech and the positive electrode behind the posterior end, the leech elongates and crawls toward the cathode. With the

poles reversed, from the above stated situation, the leech shortens and eventually orients itself by turning completely around and crawls toward the cathode.

The only reasonable explanation of this orientation is found in the application of the principle of neuron polarity to a system in which certain neurons extend parallel to the current of negative electrons when the electrodes are placed as described

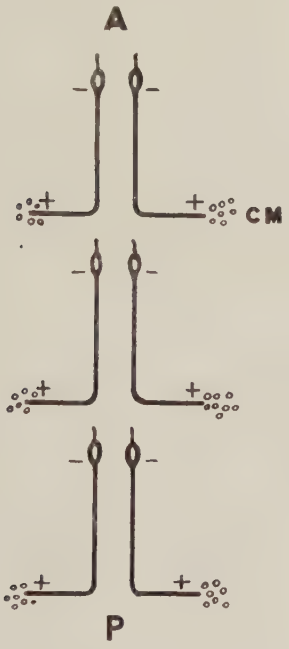

FIG.2

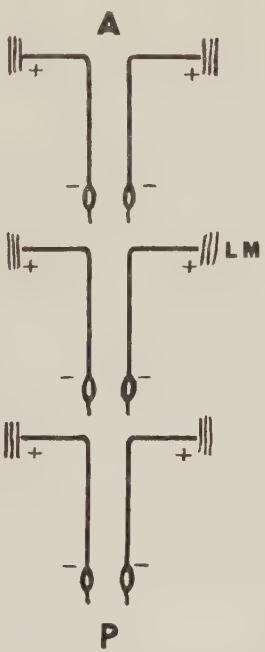

FIG.3

FIGS. 2 and 3 illustrate the polarity of motor neurons within the ventral nerve cord and their relation to the body wall muscles. A, anterior; P, posterior; C. M., circular muscles; L. M., longitudinal muscles.

above. The impulses instigated by the current travel directly over the neurons in the cord. Herein lies the experimental proof of the position of the motor neurons within the cord. (See Figs. 2, 3.)

Figure 2 illustrates the position of that group of motor neurons within the cord which innervate circular muscles. This group of neurons have their origin and highest region of gradient anteriorly. The placing of the negative electrode near

the anterior end brings about a contraction of the circular muscles. As a result of this contraction the leech elongates. This elongation is easily seen and facilitates forward locomotion. The influence of the positive electrode at the posterior end has an inhibitory effect on the longitudinal muscles. This makes shortening difficult and to some extent delays forward locomotion.

With the negative electrode near the posterior end the impulses so incited are conducted over neurons innervating the longitudinal muscles. The current running lengthwise through the longitudinal muscles as well as the neurons probably intensifies the contraction. The contraction of these muscles (longitudinal) results in a shortening of the leech. The contraction of the circular muscles is inhibited by the action of the positive electrode at the anterior end. (The turning toward the negative electrodes is explained below.)

This electrotactic response on the part of the leech can now be explained entirely on a cause and effect basis. Locomotion, by reptation, is the result of co-ordinated contractions of circular and longitudinal muscles. The contraction of these muscles is intensified or inhibited as a result of the increase in polarity of the motor neurons innervating them.

LATERAL STIMULATION

To understand the behavior of the leech when the electrodes are placed a few inches to the right and left of the mid-body region involves an understanding of the subepidermal nerve plexus.

Until recently this system was not taken into account in explaining Annelid behavior. Following the description of this system in the earthworm by Hess (1925), Shensa and Barrows (1932), applied it to the explanation of certain phases of earthworm behavior. The subepidermal nerve plexus of the leech was described by the author in 1933, making possible this explanation of leech behavior to lateral electrical stimulation.

Experiments conducted by Miller (1934) demonstrate that the longitudinal muscles on the side facing the negative electrode are stimulated directly through the motor neurons in the subepidermal plexus. The motor neurons of this plexus lie at right angles to the surface of the skin. These neurons are polarized in such a way that the longitudinal muscles on the negative are stimulated while those on the positive side are

relaxed or inhibited. Stimulation in this manner results in the leech assuming a position like that of a "C," with the anterior and posterior ends toward the negative. Prolonged stimulation in this manner results in the extension of the anterior end toward the negative electrode but does not cause the posterior end to elongate. This elongation and movement of the anterior end is explained in a preceding paragraph.

DORSAL VENTRAL STIMULATION

In response to dorso-ventral electrical stimulation the leech orients itself in the following manner. The anterior and posterior ends point toward the negative, the middle region contracts and the dorsal surface orients toward the negative. (For details see Miller, 1934.)

The negative current stimulates the longitudinal muscles through the subepidermal nerve plexus on the surface facing this electrode. This results in the leech assuming a "U" shaped position pointing the anterior and posterior ends toward the negative electrode. In this position the anterior end elongates. This elongation is the result of circular muscle contraction. The circular muscles are stimulated through impulses conducted by motor fibres in the ventral nerve cord. These neurons, as in preceding experiments, are directly influenced by the polarized field in which they lie.

The orientation of the dorsal surface toward the negative electrode is, in my opinion, a combined neuro-motor and mechanical response. The fact that the ventral series of longitudinal muscles is much stronger than the dorsal series results in a higher arching of the animal when the negative electrode is below than when the negative electrode is above. As a result of this high arching the animal rolls over bringing the dorsal surface next to the negative electrode. In the latter position the dorsal longitudinal muscles contract. The contraction of these muscles does not bring about sufficient arching to cause the animal to roll over. Hence, the animal remains oriented with the dorsal surface toward the negative electrode.

SUMMARY AND CONCLUSIONS

To complete a study of animal behavior the physical explanation of the responses of the organism is necessary. To be able to do this it is imperative that the nervous and muscular systems be well understood. Direct current of low

voltage acts as an excellent source of stimulation. Our knowledge of the polarity of motor neurons makes it possible to interpret the contraction of certain muscles as a result of the increase in polarity of the neurons innervating them. This not only reduces the understanding of behavior to cause and effect but makes possible a better understanding of the exact arrangement of the minute motor neurons within the cord, and the principles which apply to this type of behavior study.

1. The leech has a specific neuro-muscular pattern; this mechanism can be stimulated directly; the behavior of this organism is understandable (as far as these experiments permit) as the joint product of the stimulus and the reaction pattern.
2. Different expressions of behavior are due to the ultimate effects of stimuli upon different combinations of body wall muscles.
3. The behavior pattern of an organism is a recognized part of its inherited organization.
4. Animal behavior is the ultimate result of stimuli upon a particular arrangement of anatomical structures.
5. Experimental evidence obtained here demonstrates for the leech the same polarity of motor neurons as previously demonstrated for other organisms.
6. The electrotactic responses of the leech can now be explained entirely on a cause and effect basis.
7. There is an understandable physical explanation of animal behavior that becomes apparent upon the analysis of the action systems of the organism.
8. Whereas all animals may not lend themselves to behavior studies, there are forms, such as the leech, from which certain of the fundamental principles of behavior may be derived.

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BOOK NOTICES

Metropolitan Geology

It is always of much interest to find the geology of a metropolitan area taken up and discussed before the growth of the area and the destruction, accidental or otherwise, of old records makes it impossible. The author in dealing with the geology of the Minneapolis-St. Paul metropolitan area gives us first a chronological list of publications relating to the geology. The earliest is dated 1872, the last 1935. The geography of the area is discussed by Richard Hartshorne and the vegetation by F. K. Butters. The geology begins in Chapter three, where we find the section ranges from the Red Clastic Series of the Pre-Cambrian to the Galena of the Ordovician. The formations from the Galena to the Pleistocene are absent. Of the Pleistocene there are recognized six drift sheets, it being understood that these represent various lobe advances and not necessarily new advances following interglacial periods. The various drainage changes are discussed, followed by a series of short summaries by eras. The structure is taken up in Chapter four and is shown to be, in general, a main basin, the Twin City Basin. The economic products are listed as water, stone, sand, gravel, foundry sands, clays, shales, peat, and marls. None of these except water and sand are of considerable economic importance. The rest of the book is a tabulation of data on the area.

Dr. Schwartz has produced a very useful book, both for the geologist and the engineer. The area, situated as it is, is of considerable interest and well deserves the careful work represented by this publication. The 46 figures are well chosen. The 7 plates consist of two cross-sections and five maps, one a colored geologic map on a scale of 1 over 96000. We compliment both the author and the publisher of this useful and valuable book.—Willard Berry.

The Geology of the Minneapolis-St. Paul Metropolitan Area, by George M. Schwartz. Minnesota Geological Survey Bulletin 27. xi+267 pp. Minneapolis, University of Minnesota Press, 1936. $3.50.

Physics for the Layman

The bibliographer of the Bell Telephone Laboratories has extended his Lowell Institute lectures of the fall of 1935 and published them as a popular non-mathematical treatise on physics. The language has been kept extremely simple, and technical terms are introduced only after a very careful analysis of their meanings in everyday language. The facile handling of the subject is characteristic of all the author's works.

The first third of the book deals with an historical development of physics up to the opening of the nineteenth century, showing the gradual rise of the subject from "natural philosophy" to a science based on experiment. This exposition, together with the extension of a few of the subjects discussed in the first section, serve as a fitting introduction to the main thesis of the book, the transmutation of the elements, which occupies the final third of the work.

The book is carefully written in general, but we are startled to note that the New Deal has been active in the physical world, for on page 75 the acceleration of gravity has been devalued to approximately 50% of its generally accepted value! The volume is printed in very legible type, and well bound. Numerous figures and photographs help the reader in understanding the text.—J. B. Green.

The Renaissance of Physics, by Karl K. Darrow. 306 pp. New York, The Macmillan Co., 1936. $3.00.

Ecology of Insects

The other editions of this well known text and reference book in entomology have had a definite place in entomological development in the United States and Canada. Because of their lacking the recent advances in our knowledge of entomology, the third edition has been completely revised by Professor Wardle. He has added many new and recent advances to our knowledge of insects without changing the basic structure of the book in its previous editions. The main

additions have been made to the chapters dealing with Insects and Man and Insects and Disease, although a great deal of information has been added to the other chapters. Many new references have been added and some of the old ones deleted.

The revision returns this book to the preferred list of entomological texts. It is not economic in nature but stresses many interesting facts about insects which do not appear in other textbooks of the subject. The author does not stress insect classification.—R. H. DAVIDSON.

Entomology With Special Reference to its Ecological Aspects, Fourth Edition, by Folsom, J. W. and Wardle, R. A. 605 pp., 308 figs., and 5 plates. Philadelphia, P. Blakiston's Son & Co., Inc., 1936.

Electricity Without Mathematics

It is very refreshing, in these days, when almost anyone sets himself up as an interpreter of recent scientific experiments and their philosophical import, to find a book about homely electricity written by a physicist of unquestioned standing and attainment, a Nobel Laureate.

The book is a treatment of electricity such as might be given to the ordinary high school student, and indeed, is written so that such a student may readily understand it. Only the principles of electricity and the laws governing its generation and flow and interactions are discussed, with no attempt to study quantitative relationships. The material in the volume is taken from a series of six lectures given by the author at the Royal Institution (where Faraday's Laboratory was located) primarily for a "juvenile auditory" (the type of audience is seen on the frontispiece) and is well illustrated by a large number of carefully constructed diagrams and photographs.

It is the author's aim to put the fundamentals of electricity on such a **simple** basis, that a "sense" for it is developed to enable the reader to grasp easily the workings of everyday household electrical equipment; in much the same way that our mechanical sense has been developed by contact with mechanical equipment. I think that this is a habit of thinking which will take a generation to develop, for all our teachers at present have been brought up to think "mechanically" rather than "electrically" and we must wait for a new generation of teachers brought up in "electrical" surroundings before the author's aim is realized.

—J. B. GREEN.

Electricity, by W. L. Bragg. xvi+272 pp. New York, The Macmillan Co., 1936. $4.00.

Star Families in Space

Man has in effect looked at his universe three times. At first he saw it as a solar system accompanied by stars. Second, he saw it as a universe of stars with his solar system an insignificant part. A third glance has revealed it as a universe of star families scattered rather uniformly throughout space. These families are known as extra-galactic nebulae because they are objects outside of our own family or galaxy. They appear as elliptical bodies, spiral systems and barred objects. The light of the brighter and closer ones is normal, but the farther away they are the redder they appear. This effect has been interpreted to mean that all the extra-galactic nebulae are receding from each other with velocities which are proportional to their distances from each other. On this interpretation is based the idea of the expanding universe. Whether or not the interpretation is the correct one is another matter for the problem is by no means settled. Author Hubble is one of the outstanding contributors to knowledge of the nebulae and it is unfortunate that his carefully written book has been done in so pedantic a style. It is a well compiled collection of facts and ideas but lacks the vital, compelling style that such a book should have when its author has a story of his own to tell. An effort is made to present the subject matter in a semi-popular way, but in the opinion of the reviewer this has been a failure. The past tense is used throughout, and the point of view is that of the historical summarizer. The subject matter is frequently repetitious. These characteristics unfortunately have the effect of detaching the reader so that he is unlikely to see the subject intimately with the writer. This book might have been one of the finest popular accounts of contemporary science.—C. E. HESTHAL.

The Realm of the Nebulae, by Edwin Hubble. xii+207 pp. New Haven, The Yale University Press, 1936. $3.00.

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